NASA TECH BRIEF
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Improved Masers for X-Band and K_u Band

The problem:

To provide high-gain, low-noise amplifiers having wide tuning ranges at frequencies above 7 GHz.

The solution:

Traveling-wave masers which use multiple-frequency pumping and have ruby crystals oriented $\Theta=90°$.

How it's done:

The slow-wave structure of the traveling-wave maser utilizes a comb system which is comprised of ruby on one side and alumina on the other; the alumina also supports the isolator material. Radiation at pump frequency is coupled to the ruby through shaped alumina strips.

The ruby bars are fabricated from "zero degree" Czochralski ruby (0.05 to 0.07% chromium oxide) and C-axis orientation is along the length of the comb; the ruby bars are forced against a copper comb by pressure from beryllium-copper springs located between the ruby bars and the center divider of the traveling-wave maser structure. The beryllium-copper springs also serve to hold the isolators in place. Contact between the ruby bars and the comb completes a conductance path for heat transfer from the ruby bars through the copper mass constituting the body of the traveling-wave maser to a flange which supports the entire maser; the flange is in direct contact with a 4.4°K refrigerator of the type commonly used in S-band maser systems. The isolator consists of an alumina bar to which are glued yttrium-iron garnet (YIG) strips. The YIG strips are located in regions of circular polarization near the base of the comb structure.

The 90° C-axis orientation of the ruby (with respect to the magnetic field direction) determines the magnetic field and pump frequency requirements; accordingly, at X-band, a 0.5-tesla (5,000-gauss) magnetic field (uniform within ±0.0002 tesla) is provided by a superconducting magnet and the actual field across the active region of the maser is varied electrically from 0.46 to 0.52 tesla (4,600–5,200 gauss). A 0.7- to 0.8-tesla (7,000–8,000-gauss) magnetic field is used for the K_u-band maser.

Ruby crystal misorientations of the order of ±1° can be tolerated at $\Theta=90°$ without degradation of performance; as a result, orientation and assembly procedures need not be as closely controlled as with the usual 54.7-degree ruby orientation, which is 10 times more sensitive to deviations; moreover, crystal quality requirements are readily met by state-of-the-art crystal growing procedures. Efficient operation of the maser is obtained by pumping with a push-push technique; the push-push pump method with two separate pump sources as used in this development provides larger transition probabilities and higher measured inversion ratios than the push-pull method.

X-band traveling-wave maser performance has been measured over the maser's tunable range (7,750 –8,750 MHz). Net gain of 45 dB is available at any frequency in this range; the instantaneous bandwidth at 45-dB net gain is 17 MHz. A bandwidth of 50 MHz is achieved by reducing maser gain to 25 dB through the use of magnetic field-shaping coils. The equivalent input noise temperature of the maser is 6.5°K at 8,415 MHz and 8.5°K at 7,850 MHz.

K_u-band maser performance has been measured between 14,300 and 16,300 MHz. More than 30-dB

(continued overleaf)

net gain is obtainable at any frequency in this tuning range; for example, at 15,300 MHz, the net gain was found to be 47 dB with a 17-MHz instantaneous 3-dB bandwidth and an equivalent input noise temperature of 8.5°K.

Note:

Requests for further information may be directed to:

Technology Utilization Officer
NASA Pasadena Office
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Reference: TSP 73-10293

Patent status:

This invention has been patented by NASA (U.S. Patent No. 3,676,787). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to:

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